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The Utilization of Grasses and Forbs in Relation to The intensity of Grazing in The Mixed Prairie Near Hays, Kansas

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THE UTILIZATION OF GRASSES AND FORBS IN RELATION TO THE INTENSITY OF GRAZING IN THE MIXED PRAIRIE NEAR HAYS, KANSAS

being

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by

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INTRODUCTION

The principal occupation of the inhabitants in the Great Plains Region is livestock farming. The problems confronting the farmers and ranchers of this large area are many and varied. Not the least of these problems is the one of a proper stocking rate for the various types of ranges in order to secure a maximum production with the least in capital outlay and range deterioration. Another problem that has presented itself in recent years is the one of revegetating thousands of acres of marginal and semi-marginal land so that mother nature may again heal the marks of erosion and bring the land back into productivity (Great Plains Committee, 1936). This phase of the problem has been recommended by various governmental agencies such as the Agricultural Conservation Program and the Soil Conservation Service. The former agency has encouraged the reseeding of farm land by making payments for the return of cultivated land to natural vegetation. There are still many thousands of acres that should be reseeded to grasses in this region in order to afford protection for the soil.

If a good cover of highly palatable forage is to be maintained, the question of proper stocking needs further consideration. The purpose of this investigation, therefore, was to determine what species of grasses and forbs the cattle preferred under different intensities of grazing and the reason for their preference.

RELATED STUDIES

Comparatively few investigations have been made relative to the utilization of grasses and forbs with respect to the intensity of grazing. Some of these investigations have been carried on at Fort Collins, Colorado; Mandan, North Dakota; and Woodward, Oklahoma (U. S. D. A., 1943b; Black, 1937; Savage, 1943). The object of the studies at Fort Collins has been to determine experimentally the most desirable stocking rate in relation to the livestock gains per acre. The cattle used in these tests made better gains and paid more on the investment under conditions of moderate grazing. Similar studies have been followed at Mandan. The investigations at Woodward have been carried out on sandy land covered with an open type of grasses and sage brush.

The calcium content of various forbs in Utah was found to be exceptionally high when compared with that found in the native grasses of that region (Epslin, Greaves, and Stoddart, 1937). Stoddart and Greaves (1942) and Stanley and Hodgson (1938) found that the total ash percentage decreased as the vegetation neared maturity. The amount of calcium, however, did not follow this decline in the same proportion.

Dry matter has a tendency to increase throughout the season unless after a dry period, there is an abundance of moisture which causes renewed growth (Hopper and Nesbitt, 1930). Protein content fluctuates during the season, but has a tendency to become less as the season progresses (Stoddart and Greaves; Lush, 1933; Hopper and Nesbitt). In general the protein content follows in reverse order of the abundance

of dry matter (Runyon, 1943).

The protein requirement of the daily diet as set up in the Morrison Feeding Standards is 9.8 per cent crude protein for 1000 pound beef cows, 10.2 per cent for 800 pound heifers, and 12.2 per cent for 500 pound yearlings (Morrison, 1941). These percentages represent quantities needed for best production or growth.

ENVIRONMENTAL CONDITIONS

Location

The areas under consideration in this investigation are located about two and one half miles west of Hays, Kansas, Pastures A and B are on land given to the Fort Hays Kansas State College as a land grant from the federal government after the abandonment of the Fort Hays Military Reservation (Albertson, 1937). The large pasture, referred to as pasture A, was composed of 748 acres and the ravine pasture, as pasture B, covered 92 acres (FIGURE 1). Pasture B extends eastward one mile from the east side of pasture A. Pastures C and D lie across the road south of pasture A. They include 34 and 53.4 acres respectively.

Topography

The pastures under consideration have a very rolling topography with level upland at the upper extreme and with ravines and gulleys at the other. There are many different degrees of slope between these two extremes (FIGURES 2 and 3).

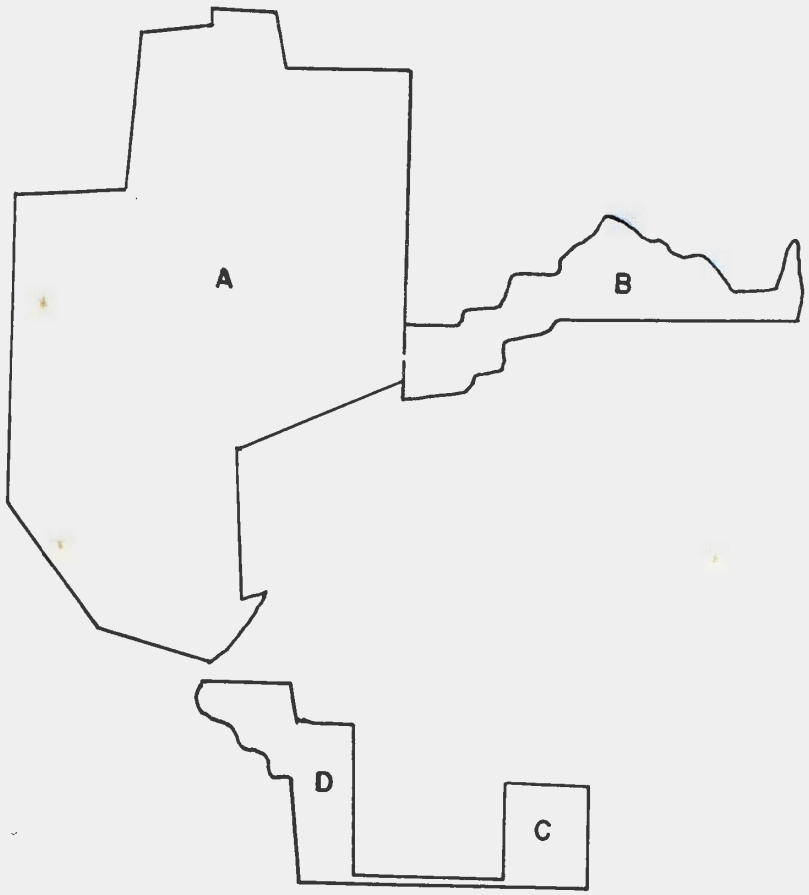

FIGURE 1.

AN OUTLINE OF THE PASTURES UNDER INVESTIGATION. THE LAND IS INCLUDED IN THE FOLLOWING LEGAL DESCRIPTIONS:
PASTURE A-- SEC. 36-T13s-R19w, SEC. 1-T14s-R19w;
PASTURE B-- SEC. 31-T13s-R18w, SEC. 6-T14s-R18w;
PASTURE C-- NW$\frac{1}{4}$ SEC. 7-T14s-R18w; and PASTURE D--
NE$\frac{1}{4}$ SEC. 12-T14s-R19w.

FIGURE 2. CATTLE GRAZING IN THE LOWLANDS OF PASTURE A.

Soil Conditions and Vegetation

The upland consisted of a comparatively tight mature soil that supported a dense cover of short grasses. These included both buffalo grass (Buchloe dactyloides) and blue grama (Bouteloua gracilis) and were about equally divided between the two.

The rocky outcrops and portions of the hill-sides overlaid only with a thin covering of soil were clothed with a fair stand of midgrasses. These included side oats grama (Bouteloua curtipendula),

FIGURE 3. A VIEW IN PASTURE C SHOWING THE GENERAL TOPOGRAPHY AND ALSO THE PREVALENCE OF HEAVY GRAZING. THE PENCIL IN THE FOREGROUND IS NEAR A HEAVILY GRAZED BROOM SNAKEWEED PLANT (GUTIERREZIA SAROTHRAE) WHILE THE WAVY LEAFED THISTLE (CIRSIUM UNDULATUM) IN THE BACKGROUND HAS BEEN UNTOUCHED.

little bluestem (Andropogon acoparius), and sand dropseed (Sporobolus cryptandrus). The side oats grama held dominance over the other two grasses at the time of study (FIGURE 4).

The dominant grasses in the lowlands and ravines are buffalo grass and western wheat grass (Agropyron smithii). Big bluestem (Andropogon furcatus), switch grass (Panicum virgatum), and Indian grass (Sorghastrum nutans) were found in the most favored places (FIGURE 5).

FIGURE 4. A GENERAL VIEW IN THE SOUTH PART OF PASTURE A SHOWING THE DOMINANCE OF SIDE OATS GRAMA ON THE HILLSIDES.

FIGURE 5. A GENERAL VIEW IN THE LOWLANDS OF PASTURE A SHOWING THE MIXTURE OF WESTERN WHEAT GRASS AND BUFFALO GRASS.

Rainfall

The rainfall during the spring and summer of 1941 was heavier than the normal rainfall for those months. The total for March to October inclusive was 24.59 inches which was 3.72 above normal (TABLE I). The rainfall for the same period in 1943 was 14.25 inches or 6.66 below normal (Flora 1941, 1943).

TABLE I. RAINFALL IN INCHES DURING THE GROWING SEASONS OF 1941 AND 1943. HAYS, KANSAS

	1941		1943	
Month	Total	Deviation	Total	Deviation
March	.58	-.35	.75	-.18
April	4.61	2.32	1.45	-.84
May	2.86	-.60	2.52	-.94
June	6.40	2.30	1.01	-3.09
July	.63	-2.54	2.83	-.34
August	4.14	1.00	2.69	-.45
September	3.02	.75	2.32	.05
October	2.35	.80	.68	-.87
Total	24.59	3.72	14.25	-6.66

Wind Movement and Evaporation

The winds during the summer of 1943 were much more desiccating than during the summer of 1941. The total wind movement for April to September inclusive was 27,012 miles during 1941 and 28,415 miles in 1943 a difference of 1403 miles (TABLE II). The evaporation from a free water surface was even more significantly greater in 1943 than in 1941. The total in 1941 from April to September was 61.81 inches while in 1943 it was 76.05, a difference of 14.24 inches (Flora 1941 and 1943).

TABLE II. TOTAL WIND MOVEMENT IN MILES AND THE EVAPORATION IN INCHES FROM A FREE WATER SURFACE FOR 1941 AND 1943. HAYS, KANSAS.

	1941		1943	
Month	Wind	Evap.	Wind	Evap.
April	5345	6.31	4949	10.17
May	4569	9.01	5143	8.9
June	4446	10.07	5461	15.36
July	3671	13.16	4461	15.77
August	3622	12.24	4371	16.16
September	5359	11.02	4030	9.69
Total	27012	61.81	28415	76.05

Available Soil Moisture

Since the rains came in small quantities throughout the summer of 1943, the moisture did not penetrate to any great depth. Consequently the available soil moisture during that time was very low and sometimes even below that available to plants (TABLE III). This condition did not exist in the season of 1941 except for a short time in July and August.

TABLE III. PER CENT OF AVAILABLE SOIL MOISTURE FOR THE SEASONS OF 1941 AND 1943 IN THE SHORT GRASS TYPE. HAYS, KANSAS.

Date	1941	1943
May 5	18.8	3.5
June 9	27.0	1.0
June 23	13.3	-.1
July 7	13.0	-.9
July 21	0.5	1.1
August 4	-1.0	2.1
August 19	10.0	-.2
September 1	10.5	-2.0

Stocking Rate

Fifty head of cattle were turned into pastures A and B on April 1 and had free run of the entire pasture throughout the season. There were eleven head of mature cows weighing approximately 1000 pounds with calves by their sides, and thirty-one head of two-year-old cows-weight 800 pounds. Some of these cows had calves by their sides. There were also eight head of 500 pound yearlings in the pasture. Figuring the yearlings as one-half of an animal unit each, there were forty-six animal units in pastures A and B. The stocking rate therefore on the 840 acres was 18.2 acres per animal unit.

Pastures C and D were stocked with sixty-eight head of cattle from May 1 to September 25 and with twenty-three head until November 1. This would give a stocking rate of 1.28 acres for the first part of the season and 3.8 for the last part. The average rate for the entire season was 1.5 acres per head.

Watering Places

The cattle in pastures A and B obtained their water from a series of ponds near the southeast corner of pasture A. Because of the scarcity of rainfall during the season, these ponds became dry about the first of August. The cattle then had to go to a well near the east end of pasture B for their water supply. During the night of September 3, however, a rain of 1.6 inches was sufficient to partly fill the ponds from run-off water.

Pastures C and D were connected by a lane approximately

one-fourth mile long joining the south side of both pastures. This made it possible for cattle in these areas to secure their water from a well in the northeast corner of pasture C. The cattle, therefore, had to travel about one and one-third miles to water when grazing in the northwest corner of pasture D.

Carry-over Vegetation

The favorable conditions that existed in 1941 and 1942 produced enough vegetation that a layer about three inches deep covered nearly all the short grass habitat in pastures A and B. No surplus vegetation, however, was present on pastures C and D in 1943 because of the heavier stocking rate during the two previous years.

METHOD OF STUDY

Measurement of Grass Utilization

Extensive measurements were made of the grasses in the pastures under consideration to determine the heights of both the grazed and the ungrazed portions. Thirteen line transects were run across pasture A and a proportionate number were run in the other areas. Each transect was run as nearly as possible across the contour of the land. This provided readings in each habitat in proportion to the relative size of the type. A reading was taken every twenty-two steps directly in front of the point of the toe on the line followed. The transects were spaced approximately 220 steps apart. A total of 675 readings was made in pasture A, 87 in pasture B, 57 in C, and 76 in D. If the plant had

been grazed, the ungrazed height of the species was obtained from the immediate vicinity.

The per cent of the forage utilized was then determined by a slide rule that had been worked out for this region by the Agricultural Adjustment Agency (U. S. D. A., 1943a). The per cent utilization is determined by the measured height of the stubble that remains after grazing in comparison to the average maximum height of the ungrazed plants.

Forb Utilization

The utilization of the forbs in the areas under investigation was measured along every second transect and at every second station on the transects used in making the grass utilization survey. A list was made of all the forbs found within a radius of three feet from the spot selected along the transect. The use that had been made of each plant was recorded as the grazed and the ungrazed heights. If there was no evidence of grazing, only the ungrazed height was recorded. The number of plants of each species was recorded for all except broom snakeweed (Gutierrezia sarothrae), heath aster (Leucelene ericoides), and prairie ragweed (Ambrosia psilostachya). These were so numerous that counting them was physically impracticable; consequently they were merely rated as abundant, numerous, or scarce.

Grass Yields

The yields of grass from all types except that of little

bluestem were obtained from records of clippings made by the Botany Department as a part of their long time research program (Albertson and Weaver, 1944). In each habitat, ten quadrats were clipped monthly and ten were clipped at the end of the season. A plot having a representative growth outside the area regularly clipped was selected and cut to obtain the yield for the little bluestem habitat. These were averaged together and the pounds per acre of air-dry material were computed for each type.

Carrying Capacity

Three random lines containing 120 stations were run to determine the carrying capacity in pastures A and B. These were also run as nearly as possible across the contour of the land in order that a fair cross-sectional observation might be obtained in each type. The readings were taken at fifty-step intervals along the lines, each reading having been made at the point of the toe. The ocular method of survey was used in making the observations for computing the carrying capacity (U.S.D.A., WD-25, 1940). The per cent ground occupied by the live vegetation was carefully estimated and the composition of the vegetation in turn was broken down into the per cent of each species present. The portion of the ground covered by vegetation is known as density. The densities and the per cent of each species was totaled and averaged separately. The average per cent of each species present was multiplied by a palatability factor (proper use factor) to determine the average palatability. The equation

for computing the number of animal units (A. U.) that should be allowed to run on the area is as follows:

$$\frac{\text{av. density x av. palatability x surface acres}}{\text{forage acre requirement x months of season}} = \text{A. U.}$$

Samples for Chemical Analysis

The samples of grasses that were analyzed chemically were collected during the summer of 1941. Collections were made from new areas every two weeks throughout the season and the clipped areas were reclipped when there had been sufficient growth to obtain a fair sample. The samples were analyzed for dry matter, ash, calcium, phosphorus, fat, fiber, nitrogen-free-extract (N. F. E.), and protein. The procedures for these analyses were taken from the Association of Official Agricultural Chemists (1940). The samples were killed by heating to 100° C. for one hour as soon as they were brought in and weighed (Loomis and Shull, 1937). For the chemical composition of vegetation on the short grass type, blue grama and buffalo grass were averaged together. The average for the midgrasses was obtained by taking the average of side oats grama and sand dropseed. Little bluestem was omitted because of its scarcity following the drought (Albertson and Weaver, 1943). Grass samples were secured also during the summer of 1943 to serve as checks against those obtained in 1941. Two portions of the grasses were analyzed and averaged together to obtain the various percentages.

Collections of the various forbs were made at the time the cattle were grazing on them. Because there were fewer samples of the

forbs, three determinations were averaged together to minimize experimental errors as much as possible. Plant specimens for each species were collected from a large area to prevent a local situation having too much influence on the results for the species.

General Observations

Periodic general observations were made throughout the season with the exception of a few weeks during harvest. Notes were made as to place and time of grazing, and what was being eaten. General observations were made also about fourteen miles north and seven east of Hays to eliminate the influence of any purely local situations which might be peculiar to the pastures under investigation.

RESULTS

Utilization of Grasses

Measurements made at the 675 stations in pasture A revealed that side oats grama appeared more frequently than any other grass with buffalo grass and blue grama in second and third places respectively (FIGURE 6). TABLE IV shows the relative abundance of these and the other grasses that were found.

Big bluestem, sand dropseed, and little bluestem were the most heavily utilized grasses in this unit (FIGURE 7). Their respective per cent utilizations were 13.1, 12.2, and 12.2, but because of their scarcity they contributed very little to the diet of the cattle (FIGURE 8). The other mid-grass, side oats grama, made the greatest

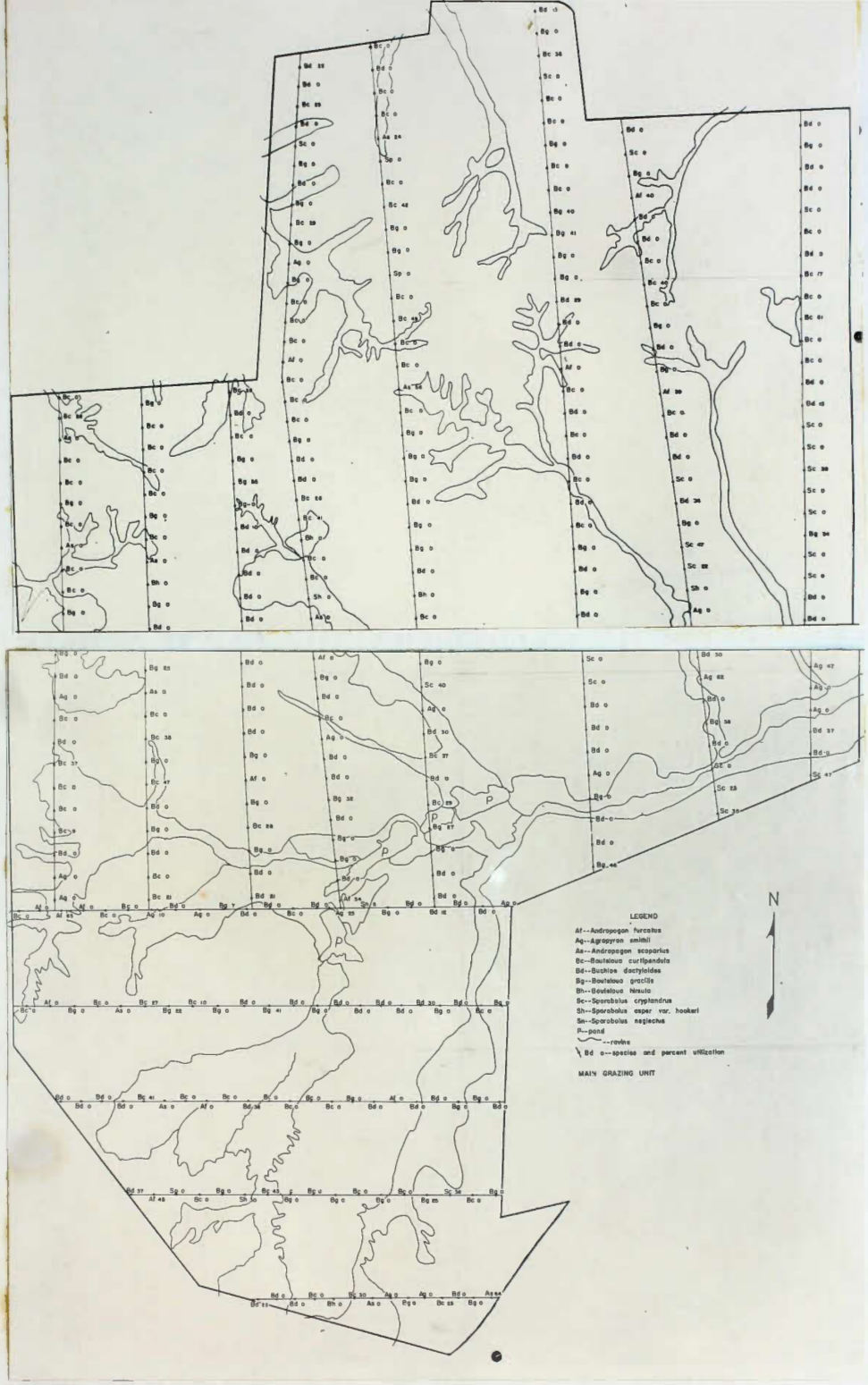

FIGURE 6. THE GRASSES AND PER CENT UTILIZATION ALONG THE VARIOUS TRANSECTS.

TABLE IV. THE RELATIVE ABUNDANCE OF EACH SPECIES OF GRASS AND THE PER CENT UTILIZATION OF EACH SPECIES IN PASTURE A.

Species	Stations	Av. per cent utilization
Agropyron smithii	34	6.7
Andropogon furcatus	20	13.1
Andropogon scoparius	33	12.2
Aristida longiseta	1	0
Bouteloua curtipendula	192	8.3
Bouteloua gracilis	148	5.8
Bouteloua hirsuta	9	6.9
Buchloe dactyloides	184	5.5
Sporobolus cryptandrus	47	12.2
Sporopolus asper var. hookeri	3	10.0
Sporobolus neglectus	2	2.5
Sporobolus pilosus	2	0
Total	675	Av. Total 7.45

contribution of the midgrasses because of its wide distribution throughout the area even though it was only 8.3 per cent utilized.

The per cent utilization of the short grasses was much less than that of the midgrasses. It was 5.8 per cent for blue grama and 5.5 per cent for buffalo grass. The average utilization at all blue grama and buffalo grass stations was 5.65 while the average for all midgrasses was 9.9. The grazing on the short grasses was very irregular (FIGURE 9). The cattle usually ate in previously grazed areas in preference to new ones. The vegetation of such places was young and more tender than the older material. The proportion of hillside readings to upland and lowland was 60, 30, and 10 per cent respectively. The average per cent utilization for these three habitats was 9.9, 5.65, and 9.9 respectively. The over-all average utilization for this pasture was 7.45 per cent.

FIGURE 7. A VIEW IN THE LITTLE BLUESTEM HABITAT SHOWING THE GRAZING BEING DONE IN THIS AREA. THE UNGRAZED HEIGHT OF LITTLE BLUESTEM WAS 15 INCHES AND THE GRAZED HEIGHT WAS 3 INCHES. THE UNGRAZED AND GRAZED HEIGHTS OF SIDE OATS GRAMA WAS 19 AND 3 INCHES RESPECTIVELY. ABOUT 33 PER CENT OF THE GRASS IN THIS LOCATION HAD BEEN EATEN. THE FORB IN THE FOREGROUND IS STIFF LEAFED GOLDENROD (SOLIDAGO RIGIDA) AND HAS BEEN PARTIALLY GRAZED.

The utilization in pasture B was more intense than in A. The most abundant species, buffalo grass, was 15.6 per cent utilized (TABLE V). Western wheat grass, the second most abundant species was utilized 16.3 per cent. Blue grama although found only at 13 per cent of the stations was 23.6 per cent utilized. Sand dropseed and Hooker's dropseed (Sporobolus asper var. hookeri) were 44.3 and 32.8 per cent utilized respectively. The average utilization in this unit was 20 per cent.

FIGURE 8. HEAVILY GRAZED SAND DROPSEED IN THE LOWLAND NEAR A CORRAL. THE GRAZED HEIGHT WAS 1 INCH AND THE UNGRAZED HEIGHT 9 INCHES. THE UTILIZATION AT THIS LOCATION WAS 6.3 PER CENT.

Pastures C and D were much more heavily utilized than either of the other two pastures. Pasture C, the one nearest the watering place, was utilized 56.2 per cent on buffalo grass and 65.8 on blue

TABLE V. THE RELATIVE ABUNDANCE AND PER CENT UTILIZATION OF EACH SPECIES OF GRASS IN PASTURE B.

Species	Stations	Av. per cent utilization
Agropyron smithii	29	16.3
Bouteloua gracilis	11	23.6
Buchloe dactyloides	34	15.6
Sporobolus cryptandrun	8	44.3
Sporobolus asper var. hookeri	4	32.8
Total	86	Av. Total 20.0

FIGURE 9. A VIEW IN THE SHORT GRASS HABITAT SHOWING THE TENDENCY TO REGRAZE SOME AREAS AND LEAVE OTHERS UNTOUCHED. THERE ARE ABOUT FOUR PLANTS OF BUFFALO GRASS TO ONE OF BLUE GRAMA. THE UNGRAZED AND GRAZED HEIGHTS OF BUFFALO GRASS WERE 6 AND 1.5 INCHES RESPECTIVELY. FOR BLUE GRAMA THEY WERE 12 AND 1.5 INCHES.

grama (TABLE VI). The buffalo grass was the dominant one of the two grasses in this unit. The average utilization for the two was 60 per cent (FIGURES 10, 11, and 12).

TABLE VI. THE RELATIVE ABUNDANCE AND PER CENT UTILIZATION OF EACH SPECIES OF GRASS IN PASTURE C.

Species	Stations	Av. per cent utilization
Bouteloua gracilis	23	65.8
Buchloe dactyloides	34	56.2
Total	57	Av. Total 60.0

FIGURE 10. A VIEW IN PASTURE C SHOWING THE HEAVY GRAZING OF A PURE STAND OF SHORT GRASSES. LITTLE BLUESTEM IN THE BACKGROUND HAS BEEN VERY LIGHTLY GRAZED. NOTE THE ABSENCE OF FORBS IN THE FOREGROUND.

Pasture D was somewhat less heavily utilized than pasture C. Buffalo grass was again the dominant species and was 48.1 per cent utilized (TABLE VII). Side oats grama was next in abundance with 64 per cent being utilized. These were followed by blue grama and sand dropseed with 48.2 and 55.2 per cent utilization respectively. The sand dropseed was not a very important factor, however, for it appeared only in 7.9 per cent of the stations observed.

TABLE VII. THE RELATIVE ABUNDANCE AND PER CENT UTILIZATION OF EACH SPECIES OF GRASS IN PASTURE D.

Species	Stations	Av. per cent utilization
Agropyron smithii	1	81
Andropogon furcatus	1	46
Bouteloua curtipendula	22	64
Bouteloua gracilis	19	48.2
Bouteloua hirsuta	3	53
Buchloe dactyloides	24	48.1
Sporobolus cryptandrus	6	55.2
Total	76	Av. total 50.0

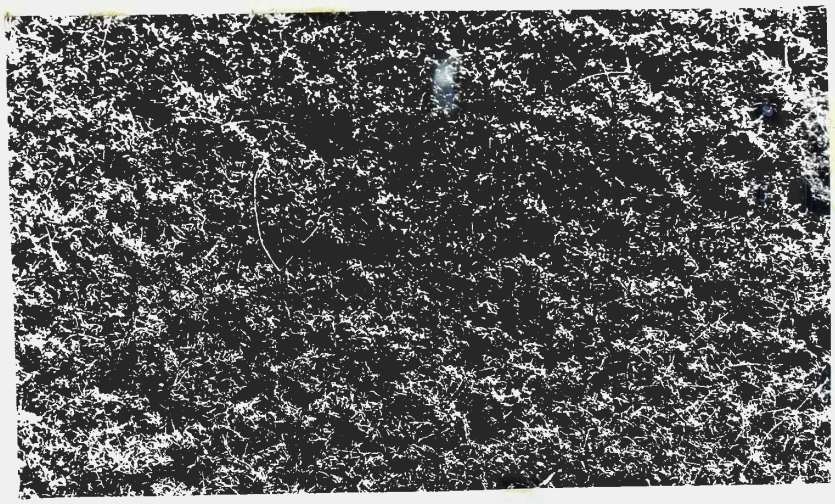

FIGURE 11. A CLOSE-UP SHOWING THE SOLID COVER OF SHORT GRASS IN PASTURE C.

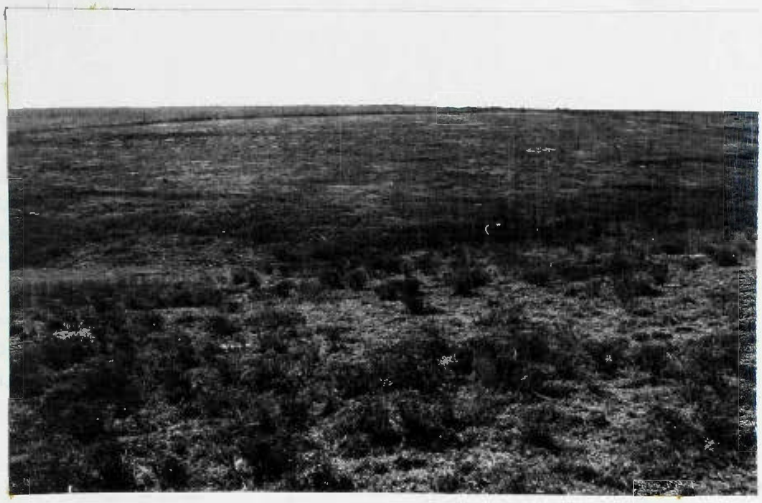

FIGURE 12. A VIEW IN PASTURE D SHOWING BUFFALO GRASS IN THE LITTLE BLUESTEM HABITAT. THE FORBS IN THE FOREGROUND ARE BROOM SNAKEWEED.

Utilization of Forbs

In comparison to the grasses, the forbs in the areas under consideration were very lightly utilized (TABLE VIII). There was evidence of grazing at about one third of the total number of stations observed during the detailed study. The plants most often utilized were velvety leafed goldenrod (Solidago mollis), lead plant (Amorpha canescens), many flowered aster (Aster multiflorus), purple prairie clover (Petalostemon purpureus), and skul cap (Scutellaria resinosa) (FIGURES 13, 14, 15, 16, and 17). Twenty-nine per cent of the height of velvety leafed goldenrod had been eaten at those stations where grazing of this species was in evidence. The per cent heights of

TABLE VIII. THE NUMBER OF STATIONS AT WHICH THE VARIOUS FORBS WERE FOUND AND AT WHICH AT LEAST SOME OF THE PLANTS WERE GRAZED.

Species	total number of stations	number grazed
Amorpha canescens	25	12
Aster multiflorus	23	9
Ambrosia psilostachya	127	2
Echinacea angustifolia	37	0
Gutierrezia sarothrae	44	0
Houstonia angustifolia	17	0
Leucelene ericoides	28	0
Liatris punctata	33	1
Malvastrum coccineum	33	3
Meriolix serrulata	42	1
Morongia uncinata	26	0
Paronychia jamesii	26	1
Petalostemon purpureus	17	6
Ratibida columnaris	19	0
Solidago mollis	14	7
Scutellaria resinosa	38	14
Thelesperma gracile	34	3
Tetraneuris stenophylla	31	0

FIGURE 13. A CLOSE-UP VIEW OF SKULL CAP SHOWING HOW THE CATTLE HAVE GRAZED ON IT. THE UNGRAZED AND GRAZED HEIGHTS WERE 9 AND 5 INCHES.

FIGURE 14. A CLOSE-UP OF STIFF LEAFED GOLDENROD SHOWING THE PARTIAL GRAZING BY CATTLE.

FIGURE 15. A VIEW OF MANY FLOWERED ASTER SHOWING GRAZED PLANTS ON THE LEFT AND UNGRAZED ONES ON THE RIGHT. THE UNGRAZED AND GRAZED HEIGHTS WERE 10 AND 4.5 INCHES.

FIGURE 16. A VIEW OF MISSOURI GOLDENROD SHOWING UNGRAZED STALKS WITH FLOWER CLUSTERS. THE CENTER OF THIS CLUMP HAS BEEN EATEN BY THE CATTLE. THE UNGRAZED AND GRAZED HEIGHTS WERE 9 AND 1.5 INCHES.

FIGURE 17. THE APPEARANCE OF LEAD PLANT AFTER CATTLE HAD GRAZED ON IT.

grazing on the lead plant, many flowered aster, and the skull cap were respectively 56, 43, and 44 (TABLE IX). The total number of species of

TABLE IX. THE PER CENT OF HEIGHT THAT WAS UTILIZED IN EACH SPECIES IN PASTURES A AND B.

Species	Per cent of height grazed
Amorpha canescens	56
Aster multiflorus	43
Solidago mollis	29
Scutellaria resinosa	44

forbs found at all locations was 55. Of this number 18 occurred at no fewer than 10 of the 183 different stations.

Only 13 species of forbs were found in pastures C and D. Of this number, seven were being utilized (TABLE X). Many flowered aster

TABLE X. THE RELATIVE ABUNDANCE OF THE FORBS IN PASTURES C AND D WITH THE NUMBER AND PER CENT OF HEIGHT GRAZED.

Species	total found	number grazed	per cent of height grazed
Aster multiflorus	4	4	57
Ambrosia psilostachya	10	5	43
Callirhoe involucrata	3	0	0
Cirsium undulatum	2	0	0
Galpinsia lavandulaefolia	3	3	60
Gutierrezia sarothrae	6	0	0

and lavender leafed evening primrose were grazed more often than any other species. The prairie ragweed (Ambrosia psilostachya) had been grazed at five of the ten stations in which it appeared (TABLE X). The per cent of the total heights grazed of the three most heavily utilized plants were 60, 57, and 43 respectively for lavender leafed evening primrose, many flowered aster, and prairie ragweed.

Yields

The short grasses furnished a larger amount of forage computed on a dry weight basis than any other type in pastures A and B (TABLE XI). The acreages for each type were computed by taking the percentage of the total number of readings for each type and multiplying that by the total number of acres in the pasture. The number of acres in each type was multiplied by the pounds per acre for that area to obtain the total yield. The total forage produced by the short grasses was 594,100

TABLE XI. THE YEILDS OF THE GRASSES FOR THE VARIOUS TYPES IN POUNDS PER ACRE IN 1943, HAYS, KANSAS

Type	Stations	Acres	Lbs. per acre	Lbs. for type
Pasture A				
Short grass on upland	163	181	980	177,300
Short grass on hillside	199	221	1386	361,000
Midgrass on hillside	243	270	1290	348,000
Short grass on lowland	27	30	1865	55,800
Midgrass on lowland	42	46	339	15,400
Pasture B	92	92	1300	119,700
Mixed Type				
Total	766	840	-	1,077,200

pounds and by the midgrasses 363,400 pounds. Pasture B produced 119,700 pounds most of which was short grasses. The yield per acre from pasture B was estimated to be only slightly less than that from the short grass plot on the hillside.

Carrying Capacity

The carrying capacity of pastures A and B was determined from the 120 readings of density and composition made along the three transects run at right angles to the natural contour. The range in density was from 5 to 60 per cent. The average density of the vegetation was 23.4 per cent and the average palatability was .675. Using the equation to determine the carrying capacity, the following is found:

$$\frac{.234 \times .675 \times 840}{.5 \times 7} = 38 \text{ animal units.}$$

The forage acre requirement for Kansas has been found to be .5 acres per animal month. This is the number of forage acres necessary to provide feed for an animal for one month (U. S. D. A., 1940). The acreage in pastures A and B allows 22.1 acres per animal unit as shown by the following equation:

$$\frac{840}{38} = 22.1 \text{ acres per animal unit.}$$

The carrying capacity of pasture C was determined from fourteen readings. The average density was 42.5 per cent and the average palatability was .32. The carrying capacity therefore would be:

$$\frac{.425 \times .32 \times 34}{.5 \times 6} = 1.54 \text{ animal units.}$$

The average density and average palatability in pasture D were respectively 31 per cent and .70. Its carrying capacity was.

$$\frac{.31 \times .70 \times 53.4}{.5 \times 6} = 3.86 \text{ animal units.}$$

The total carrying capacity for pastures C and D was 5.4 animal units

or 16.2 acres per animal unit as indicated by the following equation:

$$\frac{34 + 53.4}{1.54 + 3.86} = 16.2 \text{ acres per animal unit}$$

Chemical Composition

Short Grasses

The chemical composition of the short grasses fluctuated widely through the season (TABLE XI AND FIGURE 18). The dry matter averaged 39.5 per cent on May 17 and had a tendency to become greater as the season progressed. There was a drop, however, in the percentage of dry matter during late July and August because of a plentiful moisture supply following a dry period. This condition caused a vigorous renewal of growth. The sharp fluctuations in the percentage of dry matter and protein are due in part to the fact that on some dates several reclippings were made and on other dates only season long growth could be collected. The samples were averaged thus to simulate the actual composition of the forage taken by the cattle. The amount of protein followed more or less in reverse order to that of the dry matter. Ash increased more or less uniformly throughout the season but the percentage of calcium and phosphorus in the ash remained fairly constant. The check samples collected in 1943 showed quite similar results for the corresponding dates in 1941.

Midgrasses

The analysis of midgrasses in pastures A and B showed a very

TABLE XII. THE AVERAGE CHEMICAL COMPOSITION OF BLUE GRAMA AND BUFFALO GRASS IN 1941 AND 1943. HAYS, KANSAS

Date	dry matter	protein	fat	fiber	N.F.E.	ash	Ca.	P.
1941								
May 17	39.5	12.4	2.3	23.0	49.0	11.1	.43	.65
June 2	38.5	9.3	1.9	28.4	50.2	10.2	.44	.32
June 17	48.3	6.5	1.2	27.9	53.2	11.2	.43	.34
July 9	48.0	7.7	2.4	27.3	47.8	13.4	.40	.36
July 23	57.5	5.7	1.0	31.7	49.5	12.1	.43	.75
Aug. 6	54.4	4.8	2.2	28.7	53.4	15.1	.53	.50
Aug. 21	47.4	6.7	2.9	26.4	48.0	15.4	.42	.47
Sept. 5	43.5	10.7	3.7	29.4	43.4	13.7	.47	.58
Oct. 1	53.4	5.4	3.3	28.9	43.3	16.6	.36	.38
1943								
Aug. 11	61.0	8.4	5.7	23.8	51.0	11.1	.17	.43
Oct. 12	80.5	5.1	7.5	21.2	49.2	16.0	.36	.37

wide range in the percentage of dry matter (TABLE XIII and FIGURE 19). At the first of the season it was 30.1 per cent and increased rapidly until early August. Dry matter dropped abruptly from August 6 to 21 and then increased until the end of the grazing season. The amount of protein again followed the dry matter in reverse order. The percentages of ash, calcium, and phosphorus were similar to those in the short grasses.

Forbs

The chemical analysis of the various forbs revealed some very striking contrasts when compared with that of the grasses (TABLE XIV). All the forbs with the exception of broom snakeweed were lower in the percentage of dry matter and much higher in the percentage of fat than were the grasses. The fiber content was significantly lower also with

TABLE XIII. THE AVERAGE CHEMICAL COMPOSITION OF SIDE OATS GRAMA AND SAND DROPSEED IN 1941 AND 1943. HAYS, KANSAS.

date	dry matter	protein	fat	fiber	N.F.E.	ash	Ca	P
1941								
5-17	30.1	11.9	6.5	25.1	52.7	3.7	.46	.22
6-6	33.4	10.7	3.1	29.7	49.8	5.8	.41	.33
6-21	36.9	8.7	5.1	32.3	44.8	6.3	.27	.30
7-9	45.1	5.9	4.5	34.6	46.5	8.5	.29	.18
7-23	58.9	5.2	3.5	36.3	46.5	8.0	.27	.13
8-6	49.4	7.4	6.9	33.4	45.9	6.5	.34	.21
8-21	41.8	5.4	5.1	32.2	49.9	7.4	.28	.32
9-5	42.7	8.2	4.2	29.2	48.1	8.1	.3	.37
10-1	62.2	5.1	4.8	31.9	49.9	8.4	.31	.42
1943								
8-11	43.2	7.7	4.7	26.0	52.4	9.2	.27	.48
10-12	74.1	4.5	8.8	28.5	44.6	13.6	.65	.55

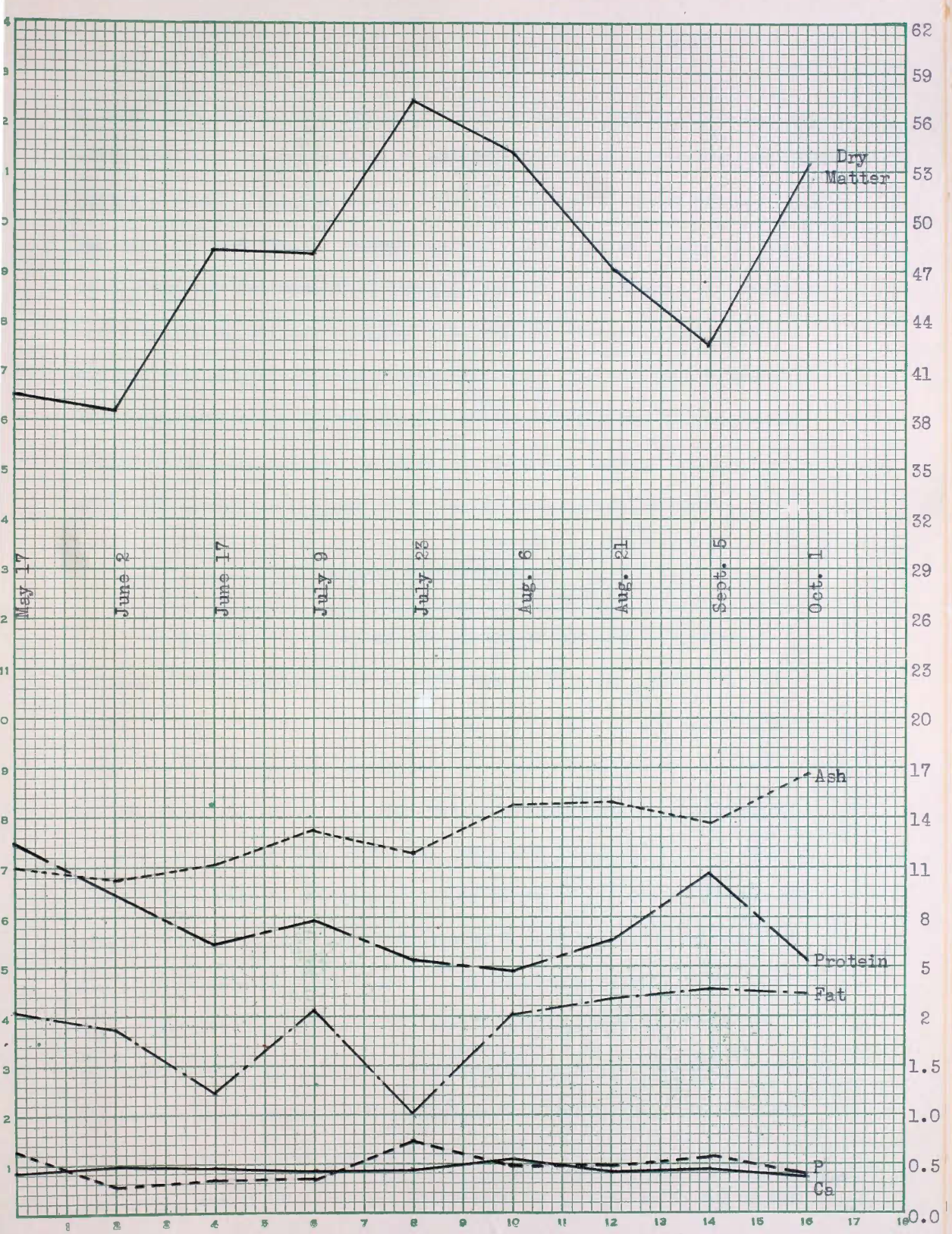

FIG. 18. FLUCTUATIONS IN PERCENT CHEMICAL COMPOSITION IN THE SHORT GRASSES.

a range from 9.6 to 22.2 per cent. The total ash was not greatly cifferent, but the percentage of calcium was definitely above that found in the grasses. Calcium varied from .24 in many flowered aster to 2.8 per cent in lead plant. Phosphorus was also especially high in the lead plant but not exceptionally high in the other forbs. A sample of broom snakeweed was collected and analyzed to determine, if possible, why the cattle avoided this particular forb. The analysis revealed a very high percentage of fat and dry matter. Otherwise the contents seemed to be very similar to those of the other forbs. The reason for their not eating this plant probably was because of its bitter taste.

General Observations

General observations of the places of grazing were made periodically throughout the season. Nearly all the grazing on the short grasses was done during early and mid-season. The short grasses went into a semi-dormant condition about July 1 and became quite dry and harsh to the touch. An observation made August 4 revealed much grazing on big bluestem, side oats grama and skull cap. There was insufficient rain to maintain a supply of water for the cattle in the ponds; hence from August 1 to September 4 they had to go to the east end of pasture B to obtain water. The temperatures were quite high during the day; consequently the cattle grazed almost entirely in pasture B during that period. Observations were recorded as to where the cattle were grazing on thirty-eight different days. On sixteen occasions they were on pasture B, eight times on the lowlands of pasture A, twelve times on the midgrasses of A, and two times on the

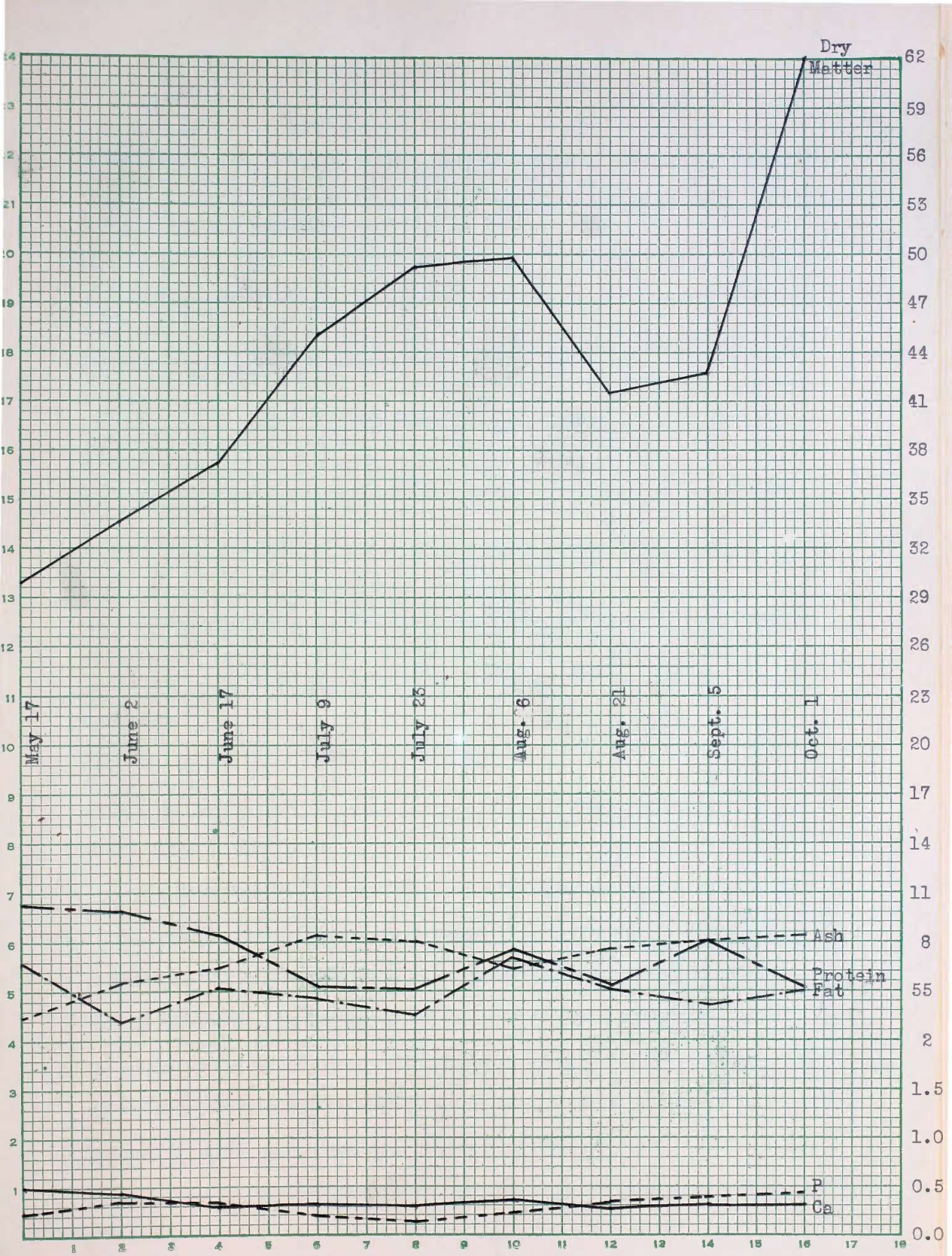

FIG. 19. FLUCTUATIONS IN PERCENT CHEMICAL COMPOSITION IN THE MIDGRASSES.

TABLE XIIV. THE CHEMICAL COMPOSITION OF VARIOUS FORBS IN THE PASTURES UNDER INVESTIGATION. ALL THE FORBS WERE BEING EATEN AT THE TIME OF THEIR COLLECTION WITH THE EXCEPTION OF SOLIDAGO RIGIDA ON SEPT. 17, 1943 AND GUTIERREZIA SAROTHRAE ON OCT. 12, 1943.

Date and species	dry matter	prot.	fat	fiber	N.F.E.	ash	Ca	P
Aug, 11, 43 Solidago rigida	25.6	6.9	11.6	15.5	60.1	5.9	1.3	.52
Sept. 17, 43 Solidago rigida	38.6	7.8	10.5	9.9	63.9	7.9	1.1	.48
Sept. 17, 43 Soutellaria resinosa	41.7	4.2	10.2	19.5	55.1	11.0	1.2	.45
Oct. 10, 43 Aster multiflorus	49.0	9.1	14.3	22.2	46.5	7.9	0.2	.43
Oct. 11, 43 Amorpha canescens	55.7	8.2	8.5	21.5	51.4	10.4	2.8	.92
Oct. 11, 43 Solidago mollis	45.2	8.8	13.8	12.7	56.4	8.3	1.1	.70
Oct. 11, 43 Solidago glaberrima	46.7	10.4	17.2	9.6	44.3	7.1	1.0	.33
Oct. 12, 43 Gutierrezia sarothrae	74.2	7.7	14.0	19.9	50.0	8.4	0.7	.60

short grass upland of A.

A series of check observations were made on August 14 in the mixed prairie about fifteen to twenty miles northeast of Hays. The purpose of these observations, as mentioned in the method of study, was to eliminate the influence of any purely local situation peculiar to the pastures under study. One pasture that had been lightly utilized showed very little evidence of grazing on the short grasses. The bunches of side oats grama and little bluestem had been rather consistently grazed. The midgrasses were producing an abundance of flower stalks.

Another pasture about one mile from the above mentioned range was utilized much more heavily. The average height of the side oats grama and little bluestem stubs was 1.5 inches. They were producing flower stalks at the rate of one for about every ten plants. The short grasses had been grazed much more heavily than in the other pasture but not as closely as were the midgrasses. Blue grama was producing an abundance of flower stalks at that time.

These observations confirmed those made in the areas under the intensive study that the cattle were grazing consistently on the midgrasses in preference to the short grasses.

DISCUSSION

The utilization measurements in any or all of the pastures under observation seem to indicate a very decided preference for the midgrasses instead of the short grasses. The thing which seems to have been the determining factor was a moisture relationship. The midgrasses with their roots reaching moist subsoil were able to maintain a nearly normal growth all summer while the more shallowly rooted short grasses went into semi-dormancy by July 1. The chemical analyses showed a much lower percentage of dry matter in the midgrasses than in the short grasses except in the samples collected on October 1. These samples of midgrass were higher in percentage of dry matter than the short grasses. This condition existed because the midgrasses had gone into dormancy while blue grama had emerged from semi-dormancy and had some green leaves near the ground.

All grasses, except during the earliest part of the season, were lower in protein than is desirable for rapid growth of young cattle or to furnish an abundant milk supply for suckling calves. Some of the forbs, notably lead plant, stiff-leafed goldenrod, Missouri goldenrod, velvety leafed goldenrod, and many flowered aster, no doubt, contributed a portion of the protein but could have been only a minor factor because of their relative scarcity.

Probably the greatest contribution of the forbs in these pastures was the calcium and phosphorus which they furnished for the cattle. Nearly every forb grazed was exceptionally high in calcium and rather high in phosphorus.

The observations in the lightly grazed pastures A and B in comparison with those in the heavily grazed pastures C and D indicate a difference in the preference for the different grasses and forbs. There were practically no forbs in pasture C in the fall of 1943 because they were grazed to the ground. The light grazing in the spring of 1944, however, allowed those that were still alive to renew their growth. There were large numbers of wild alfalfa (Psoralea tenuiflora) and salmon colored mallow (Malvastrum coccineum) all over this area. The cattle had also grazed lavender leafed evening primrose in pasture D while there was no evidence of its being grazed in pasture A or B. One of the forbs, Houstonia (Houstonia augustifolia), in pasture A was not being utilized at any of the stations in the forb utilization survey, but general observations revealed some grazing being done on that species (FIGURE 20).

FIGURE 20. THE TYPE OF GRAZING BEING DONE ON HOUSTONIA. Because of a lack of forage, the cattle were grazing some of these less desirable plants consequently, the short grasses and many forbs were more heavily grazed in pastures C and D than in pastures A and B (TABLES IV, V, VI, VII).

The persistence shown by the cattle in grazing skull cap, the goldenrods, aster, and lead plant has led to the belief that these plants could very profitably be included in revegetating an area if the soil and climate are conducive to their growth.

The very low carrying capacity as determined in this survey has probably resulted from the excessive amount of surplus vegetation carried over from 1942. The old grass had fallen down and caused the short grasses to lose their density to a great extent. There is

also the possibility that the forage acre requirement is too high for a pasture of this type. This factor, however, is computed from the average of a large area over a period of several years.

The great difference in the computed carrying capacity and the actual stocking rates in these pastures is hard to explain with no more evidence than is available from this investigation. The large surplus carry-over vegetation may have been a factor in pasture A. There was no surplus residue, however, on pastures C and D and still the actual stocking rate was much higher than the computed carrying capacity.

The data from this investigation show a strikingly low daily forage consumption. The yield of short grass in pasture A was 594,100 pounds and was utilized 5.65 per cent. According to these figures the total consumption would be 33,600 pounds. The midgrasses produced 363,400 pounds and were 9.9 per cent utilized. The forage consumed on this type would be 35,737 pounds. Pasture B produced 119,700 pounds and was 20 per cent utilized. This would give only 23,970 pounds to be consumed. The total amount of feed consumed according to these figures was 93,307 pounds and would provide only 9.5 pounds of grass for each of the 9860 animal unit days. The calculated amount of forage eaten, however, is only about one half of the necessary amount as stated in the Feeding Standards.

If 93,307 pounds of forage represented the total consumption the total short grass forage eaten by the cattle was 57,570 pounds, and the midgrass forage 35,737 pounds. The percentage, therefore, of

the daily diet for each type of grass was 61.8 and 38.2 for short grass and midgrass respectively. Since from these figures the cattle ate an average of 9.5 pounds of grass per day, 5.9 pounds was short grass and 3.6 pounds was midgrass. Referring again to TABLEX XI and XII for the composition of the grasses, the cattle on May 15 would have obtained only .73 pounds of crude protein from the 5.9 pounds of short grasses and only .43 pounds from the 3.6 pounds of midgrasses. This would give a total of 1.16 pounds per day of crude protein. The supply in the plants decreased until, on October 1, the cattle were getting only .32 and .18 pounds per day from the two types or a total of .5 pounds. Morrison recommends 1.25 to 2.0 pounds per day for cattle of these kinds. During the early part of the growing season, therefore, the protein in the grasses was below the requirements as set up by Morrison and later in the season when the protein content was less the deficiency was even more pronounced.

The cattle were doubtless deriving some forage from the forbs and old vegetation but it was impossible to measure the quantity thus consumed. There was also a possibility that the yield over the entire type may have been somewhat higher than the yield from the clipped areas. Another source of possible discrepancy was in making the utilization checks on the short grasses. These grasses, when heavily utilized during the early part of the season, would show no apparent grazing effect at the end of the season because the leaf ends have a tendency to ripen and fall off the plant to be replaced by new growth. Thus the evidence of grazing might be entirely lacking.

The areas most heavily utilized were those nearest the watering places. This was very evident in pasture A where grazing was most intense in the lowlands near the ponds. Pasture B was more heavily utilized than pasture A because of its size and the necessity of obtaining water there for about eight weeks. The area in pasture B nearest the water supply was, likewise, grazed much heavier than that farther away. The same situation existed in pastures C and D where 60 and 50 per cent of the forage had been utilized respectively. The heaviest utilization was again near the watering place.

SUMMARY

The data obtained in this investigation have indicated

1. A preference by the livestock for the midgrasses rather than the short grasses. The midgrasses maintained growth and retained a high moisture content for a longer period of time.

2. The per cent of protein, calcium, and phosphorus was usually higher in the forbs than in the grasses.

3. The various forbs furnish substantial amounts of protein, calcium, and phosphorus for livestock.

4. It was impossible to determine the amount of old vegetation consumed by the animals.

5. The computed carrying capacity as calculated according to rules of the Agricultural Adjustment Agency is very conservative when compared with the actual stocking rate and the per cent of actual utilization in these pastures.

6. An accurate check on the per cent utilization of forbs is extremely difficult. When eaten to the ground, they may remain dormant during the rest of the season.

7. Grazing on lightly utilized pastures is heaviest near the watering places. The remote areas often show very little or no apparent grazing.

8. Cattle utilize more species of grasses and forbs in heavily grazed areas than in those lightly grazed.

9. Cattle graze more uniformly on the heavily utilized areas than on lightly grazed ones. On the lightly utilized pastures, the grazing is spotted because of the tendency of the cattle to graze and regraze small places where the vegetation remains green and succulent.

10. The possibility of adding seed of desirable forbs to revegetation planting mixtures to furnish supplements of protein, calcium, and phosphorus for the grasses.

Scientific and Common Names of Species Mentioned in the Manuscript.

Agropyron smithii	Western wheat grass
Ambrosia psilostachya	Prairie ragweed
Amorpha canescens	Lead plant
Andropogon furcatus	Big bluestem
Andropogon scoparius	Little bluestem
Aristida longiseta	Red three-awn
Aster multiflorus	Many flowered aster
Bouteloua curtipendula	Side oats grama
Bouteloua gracilis	Blue grama
Bouteloua hirsuta	Hairy grama
Buchloe dactyloides	Buffalo grass
Callirhoe involucrata	Purple poppy mallow
Cirsium undulatum	Wavy leafed thistle
Echinacea augustifolia	Purple cone flower
Galpinsia lavandulaefolia	Lavender leafed evening primrose
Gutierrezia sarothrae	Broom snakeweed
Houstonia angustifolia	Narrow leafed houstonia
Leucelene ericoides	Heath aster
Liatris punctata	Blazing star
Malvastrum coccineum	Salmon colored mallow
Meriolix serrulata	Serrate leafed evening primrose
Morongia uncinata	Sensitive brier
Paronychia jamesii	James whitlow-wort
Petalostemon purpureus	Purple prairie clover
Psoralea tenuiflora	Wild alfalfa
Ratibida columnaris	Prairie cone flower
Scutellaria resinosa	Skull cap
Solidago glaberrima	Missouri goldenrod
Solidago mollis	Velvety leafed goldenrod
Solidago rigida	Stiff leafed goldenrod
Sporobolus asper var. hookeri	Hooker's dropseed
Sporobolus cryptandrus	Sand dropseed
Sporobolus neglectus	Annual dropseed
Sporobolus pilosus	Hairy sporobolus
Tetraneuris stenophylla	Tetraneuris
Thelesperma gracile	Rayless thelesperma

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